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ABSTRACT

The aim of the Math/Science Workshop Program was to improve the performance of the University of California (UC) Berkeley minority students in freshman- and sophomore-level mathematics and science courses, and thereby increase the number of such students who continue on to complete bachelor's degrees in "mathematics-based" fields. It is also intended to serve as a model affirmative action program for other institutions seeking to improve the performance and persistence of minority undergraduates in scientific and technical fields of study. This report contains an executive summary and: (1) project overview; (2) project purpose; (3) background and origins; (4) project description; (5) outcomes and impacts; and (6) summary and conclusions. Findings show that the project (which provided supplementary instruction, academic counseling, and other services) appeals to well-motivated, high achieving students. It sets high goals for them, teaches them to work both independently and in groups, and in so doing, prepares them for the kind of work conditions that are frequently encountered in research laboratory and high technology think-tanks. The program demonstrates that Blacks and Hispanics can compete successfully with the nation's very best students both at UC Berkeley and elsewhere. (JN)

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Final Report to FIPSE
on
University of California, Berkeley's
undergraduate honors program
for minority mathematics and science students--
The Math/Science Workshop Program

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SE 046 429

Final Report

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Project Dates and Amounts

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Year 3	8/1/82-1/31/84	$146,941
	42 Months Total	$384,745

MATH/SCIENCE WORKSHOP PROGRAM

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A. Project Overview

In Fall, 1980, U.C. Berkeley's Professional Development Program (PDP) received a three-year FIPSE grant of $386,405 to develop the Math/Science Workshops, an academic support program for minority undergraduates in engineering, the physical sciences, and other technical fields. The program provided supplementary instruction, academic counseling, and other services to a majority of such students on the Berkeley campus. It has served as a model for similar programs on other campuses.

B. Purpose

The aim of the project was to improve the performance of U.C.Berkeley minority students in freshman-and sophomore-level mathematics and science courses, and thereby increase the number of such students who continued on to complete bachelor's degrees in "mathematics-based" fields. It was also intended to serve as a model affirmative action program for other institutions seeking to improve the performance and persistence of minority undergraduates in scientific and technical fields of study.

C. Background and Origins

Research by the PDP staff had shown that very few minority students were successfully completing Berkeley's rigorous introductory calculus sequence which thus constituted a virtually impassable barrier to minority students seeking careers in engineering, the sciences, medicine, or business administration. Moreover, it was found that traditional remedial methods, such as individual tutoring, were not effective in enabling these students to pass, much less excel at, freshman calculus. Finally, the PDP staff discovered that the difficulties of the transition from high school into the academic and social life of the university, including problems of isolation and inefficient organization of study-time, were at least as much a factor in minority student's poor mathematics performance as inadequate academic preparation. The Workshop program was conceived as a non-remedial "honors" program that would enable participating students not merely to pass their introductory calculus courses but to perform at a high level in them and go on to complete degrees in their fields of choice.

D. Project Description

The Workshop porgram was intended to create an environment within which Black and Hispanic students would excel at college-level mathematics-intensive science courses. Towards this end, the program had four primary objectives:

1. to build a community of minority freshman focused on achieving academic excellence, and providing a source of peer support;

2. to provide extensive supplementary instruction for participating students throughout the academic year;

3. to orient minority students to the University and to assist their adjustment to campus life and, when necessary, to advocate their collective and individual interest;

4. to monitor students' academic progress and to furnish ongoing academic and career advising.

The key to accomplishing these goals was the organization of participating students into small study groups that met regularly during each academic term. These groups were arranged to accompany regular University courses in mathematics, physics, chemistry and computer science. They provided a forum within which students could work on homework problems, discuss results and critique one another's work, and ensured that students both devoted adequate time to school work and had an opportunity to meet and socialize with their peers. Moreover, the frequency of Workshop leaders' contact with students enabled the leaders to closely monitor students' academic progress and adjustment. Unlike university counselors or advisors who typically see students only when they are in trouble, the workshop leader offered timely advice on the spot and addressed problems in the making--such as housing arrangements or delayed financial aid--before they became crises.

E. Outcomes and Impacts

Workshop students have consistently outperformed their non-workshop minority classmates in the target mathematics and science courses. Moreover, participating students have, on the average, also outperformed their White and Asian counterparts in these courses. The persistence of Workshop students in scientific and technical fields of study has also been significantly better than that of both non-participating minority students and the campus undergraduate student body as a whole. Finally, programs modelled on the Workshop have been developed on several other campuses of the University of California, Michigan and Darthmouth College; these programs have had results comparable to, or better than, Berkeley's in improving the performance and persistence of participating students.

F. Summary and Conclusions

In sum, PDP appeals to well-motivated, high achieving students. It sets high goals for them, demands hard work from them, but organizes this work in highly efficient fashion. It teaches students to work both independently and in groups, and in so doing, prepares students for the kind of work conditions that are frequently encountered in research laboratories and high technology think-tanks the world over.

But in many respects PDP's methods are not as significant as its accomplishments. At the heart of the program is the assumption that Black and Hispanic students can succeed in mathematics if excellence is demanded of them and if means to achieve excellence are provided. The program demonstrates that Blacks and Hispanics can compete successfully with the nation's very best students both at U.C.Berkeley and elsewhere.

A. Project overview -- See Executive Summary

B. Purpose -- See Executive Summary

C. Background and Origins

In surveying the educational path leading from San Francisco Bay Area elementary schools to graduate or professional programs at UC Berkeley, PDP's attention became focused on a particularly significant barrier to previously successful minority students: Berkeley's rigorous one-year calculus sequence. This sequence (Calculus 1A, 1B) is the first year of a two-year mathematics sequence which plays a pivotal role for science and engineering students: it is a prerequisite for all engineering and physical science majors, and it is the preferred calculus sequence for business administration and biological science majors. Charts I & II show the performance of all Black students since 1973 and all Chicano students since 1976 in Calculus 1A and 1B. As the charts show, in every year prior to the creation of the Mathematics/ Science Workshop in 1978, the average grade of Black and Chicano students was well below the class average, and in many years, below the University's minimal acceptable scholarship level as well. Equally important, but not reflected in the charts, is the fact that more than one-fourth of the minority students who attempted Calculus IA during these years dropped the class before completing it, and therefore, did not earn a grade.

Some minority students entered Berkeley with less exposure to mathematics than their classmates and, because of low academic standards in their high schools, with deficient study skills as well. Others, of course, had attended solid college-preparatory high schools and were, by all standard admissions requirements, well prepared for University-level work. Clearly, background preparation alone could not explain the dismal statistics shown in charts I and II.

In looking for common characteristics that might help to explain the puzzling lack of success among such a diverse groups of students, (see charts I & II, prior to 1978) PDP's attention was drawn to the almost religious separation these students maintained--regardless of their class or educational background--between their school lives and their social lives. The insularity of these students hindered their academic success. The informal study groups common among majority students were vehicles for academic socialization; they enabled students both to "check out" their understanding of university and class requirements and to normalize their attitudes and behavior. Composed of students with shared purpose, these study groups were efficient mechanisms for gathering the institutional and mathematical knowledge necessary for academic success. Equally significant is the fact that they were an important source of encouragement and emotional support in what is, for students of all ethnicities, a period of difficult personal adjustment.

Without such a community of peers, the minority student faced alone the formidable demands, both academic and personal, of the freshman year. His isolation from his peers perpetuated a debiliting non-fit between his perceptions of what was required and the actual requirements of the institution--both academic and social.

Of course, UC Berkeley, like most other colleges and universities, provided its students with such academic and personal support services as counseling, faculty advising, and remedial tutoring. But many minority students misunderstood the purpose of these services. It was commonplace, for minority students to take as directives what advisors intended as suggestions, a misunderstanding that decreased the advisors' value to the student in trouble--especially when conflicting suggestions came from different advisors. Similarly, because many minority students believed that the Counseling Center was a college version of their high school counseling office, they rarely sought its help in times of trouble. For many of these students, remediation was an anathema: they associated it with the non-academically oriented students in their high school, with the discipline problems, with the non-serious students.

From this account, we see that for many minority science and engineering students, some of whom were lacking strong academic backgrounds, and most of whom were lacking a supportive academic peer group and knowledge of how to use campus support services effectively, the freshman year presented insurmountable demands. In the face of these demands, such students were compelled to reevaluate not only their academic and professional plans, but also a core belief that enabled many of them to get to college, namely, that their intelligence and dedication alone would enable them to succeed. Many withdrew; others transferred into majors that were less demanding but that held little interest for them. Of those that did continue in the sciences or engineering, the majority were eventually dismissed.

D. Project Description

The picture that emerged from PDP's study of minority freshmen at Berkeley made it clear that an effective intervention strategy had to focus not only on mathematics learning per se, but also on the range of other difficulties that minority freshmen face at Berkeley. PDP's strategy, described below, challenged remedial approaches to assisting minority students and provided instead a novel "honors" program promoting academic excellence. The core of the strategy is the excerise of four functions. In what follows, first we delineate these functions and the Math/Science Workshop activities that have corresponded to each. Second, we describe, somewhat colloquially, a typical workshop session: how it appears to the outside observer, and the responsibilities of instructors and participants.

(1) Building a community of minority freshmen that is focused on academic excellence and achievement and is a source of peer support.

In the Math/Science Workshop, students were immersed in highly structured, intensive group activities--even before the beginning of academic terms--and study groups formed before classes started, giving students time to get to know each other, and to learn how to work together, before they were beset by the pressures of the academic term. Fifteen hours per week of group activities were blocked into participating students' schedules so that there was time for both academic and social activities.

These study groups have enabled minority students to carry on much of their academic work within an immediate community of their peers. Workshop staff members taught participants how to get from their "in-group" a variety of ingredients essential for academic success ranging from a knowledge of how to maneuver within the institutional "system," to an understanding of specific concepts under study in a course. The organization of working groups within the Workshop was contrived to take account of differences in ethnicity, economic class, and preparatory academic background, so as to maximize the benefit to each participating student.

By reducing the insularity of the Workshop students these study groups have both enriched the academic experience for participants--thereby improving their performance--and eased their transition into university life. In addition, the group format of the Math/Science workshop is a cost-effective means for delivery of supplementary instruction by staff members, and it allows the students themselves to assume an instructional role in their interactions with one another. The students' opportunity to explain mathematical concepts and problems contributes significantly to their own learning.

An important feature of the Math/Science Workshop has been its non-remedial emphasis, made possible by carefully placing students in courses for which they have adequate prerequisites. In this way, the Workshop has maintained an atmosphere of academic achievement and excellence. When an individual student has needed remediational study, the Workshop has arranged for individual study sesssions, often in conjunction with one of the regular campus units available for such service.

(2) Providing minority students with an extensive orientation to the University, and with on-going academic advising.

The Math/Science Workshop included a wide range of activities which helped students learn to perceive correctly the norms, demands, and requirements of the institution. Before students' first academic term (during their first week on campus), each student was interviewed in depth and given an appropriate mathematics screening test. In the initial orientation sessions and interview, students were told how their academic preparation compared with that of their classmates (minority and non-minority), and what would be expected of them in courses, e.g., number of hours of study weekly in each course, and standards for homework. On the basis of these contacts, each student was helped to design an appropriate academic plan for his/her freshman year.

During the academic year, Workshop staff members served as informal advisors: they were in almost daily contact with the Workshop students and were trained to recognize common problems that interfere with minority students' academic success. Students with potentially serious problems were referred to the Workshop's coordinator or director; when necessary, these individuals refered students in turn to a campus Counseling Center or EOP (Educational Opportunity Program) specialist.

(3) Monitoring of both students' academic progress and their adjustment to the University environment, and advocating students' collective and individual interests.

The Math/Science Workshop staff followed closely Workshop students' progress and performance in their classes, including their homework and test scores, their understanding of important mathematical concepts, etc. This close monitoring was important because it enabled the staff to identify and deal with problems quickly. Monitoring was thus closely tied to the Workshop's orientation, advising, and instructional activities. Workshop staff members acted as advocates both for individuals in the Workshop and for the Workshop community. Formal ties were established between PDP

and the campus academic and administrative rentention units; key individuals in these other campus units offered special assistance to Workshop participants.

(4) Providing minority freshman with extensive and ongoing supplementary instruction.

The Math/Science Workshop used a variety of special formats developed by the PDP staff to provide Workshop students with both supplementary mathematics instruction and instruction in three target skills:

a. reading the technical language in which university mathematics texts are written,

b. writing homework, tests, and laboratory assignments in standard mathematical language and form,

c. accurately assessing the extent of one's understanding of mathematical concepts and problems.

The Workshop instructors typically have had advanced graduate training in mathematics or science, experience in teaching at the university level, and experience in working with minority students. Many of these individuals have been graduate students in Berkeley's Ph.D. program in science and mathematics education.

The ultimate aim of the Math/Science Workshop was to develop participating students into independent learners so that they can function effectively in the mainstream of the University beyond their sophomore year. It was toward this end that the Workshop leader encouraged and guided his/her students in their academic work and in their interaction with faculty, teaching assistants, and classroom peers.

A WORKSHOP SESSION

A typical workshop session most resmbles a lively science-club meeting. The noise-level is higher than that in a class-room or lecture, as there are many students talking in small groups at once. Typically, approximately three-fourths of the students will be discussing math, their classes or joking with one another. The rest of the students will be working individually on a problem. Groups are not fixed, so there is some movement in the room as students get up to examine each others work or leave a group to work on their own. The Workshop leader is usually circulating unobtrusively, alert to the dynamics of the clusters of students, all of whom are wrestling with a set of problems on a worksheet. From time to time the leader will sit down, a short distance behind a group of three or four students. If they have no questions, the leader will observe them without commenting. If they have hit a snag, they may ask for a hint as to how to proceed. Moving from group to group the leader can constantly monitor the students progress by watching them in the act of solving problems.

A workshop is not just a place where students gather to study outside of class, nor is it an extra recitation section. Usually the the leader will instruct the workshop as a whole only during the last twenty minutes of a two hour session. During the rest of the time both the students and the leaders have carefully defined responsibilities for making the period of group study productive.

The Students' Responsibilities

The students are responsible for attending regularly. Sporadic attendance not only would diminish the absent student's opportunity to profit from the workshop, but would also undermine the sense of community that the workshop is intended to encourage. A student must call in to explain the reason for missing a session--illness or perhaps a test in another subject the next day. Although the best students may correctly decide that they do not need to come to every session, two consecutive absences often indicates that a student is not on top of the material and is having difficulty with the course.

Before attending the workshop the students are responsible for doing all the classwork they are able to do on their own. They should come with as much of the homework completed as possible, having read the assignments and reviewed their lecture notes. They can then participate actively in the workshop. If the student comes to the workshop unprepared, it will be apparent to the workshop leaders.

During each session some time can be spent on homework problems, and students can request help with the problems they have not completed. Some of the worksheet tasks will be devoted to breaking down homework problems into manageable steps. But the main purpose of the session is not to do course assignments but to reinforce concepts and skills by doing extra work: problems xeroxed from old tests that treat material now being studied, extensions of homework problems that introduce more advanced topics, problems that will lead into the planned instruction for the last portion of the workshop.

The worksheet is the vehicle for involving the student in groups, but there are no fixed rules about how they must proceed. Some will elect to start off alone, joining others after a period of quiet thought or exploratory attempts at a problem of their choice. At any one moment, and within a session individuals may spend part of the time in one group and then leave to work with another. As they work together, they alternate giving and receiving assistance. Since the problems are designed to be tough, there is no stigma attached to asking a fellow participant for help, and the students quickly appreciate the chance to compare papers to see the methods and approaches others take to the same problem.

The students are responsible for critiquing one another's work. To do this, they must become more articulate critics than they are usually accustomed to being; they must refuse to accept an answer unless they can see why it is correct. It is not unusual at the first sessions for

the students in a group to be impressed by one member who is particularly assertive, even when wrong. Nor is it atypical for several students to insist that they have the same answer when they are patently at odds. The desire to agree--and to be agreeable--overrides their critical perceptions. But as they continue, they learn to question and to demand explanations. Then they are more ready as well to defend their own ideas.

The Leader's Responsibilities

Leaders must, of course, be throughly trained in the discipline that is the subject of a workshop. They do not, however, use workshop time to duplicate the sort of instruction the students receive from a teaching assistant in a recitation section. Instead of standing at a blackboard and demonstrating their expertise or taking the students step-by-step through examples, they design the tasks the students will work on, and they assist the students in learning how to work together.

Deciding what the students should concentrate on in each workshop is one of the leader's most important responsibilities. Observation of the students as they actually do the problems reveals that they need to expend more effort in certain areas without unnecessarily repeating already familiar procedures. The leader also frequently request feed-back from students on an informal basis outside the workshop.

The strategy in planning the worksheet is to keep the students challenged with tasks that they recognize to be useful for their better understanding of the course material. The problems are set up so that students will get stuck or come to incorrect conclusions. Then the leader can offer obviously useful instruction. There is almost always a problem so difficult that no one can tackle it, and rarely is a worksheet finished. But at the end, when the students have all worked on some of the same problems, the leader will discuss them, often pointing out tricks that the textbook does not cover.

At a weekly curriculum meeting all the leaders of workshops in one subject construct the worksheets for the next sessions. They analyze the course curriculum and the demands it makes on the students' mathematics background and problem solving skills. They design the worksheets accordingly. Along with problems linked to the upcoming weekly homework assignments, worksheets typically include examples of confusing test questions, as well as problems that might look easy but that are quite difficult and viceversa. Putting together the worksheets for each week usually takes three to four hours (see sample worksheets in Appendix B).

At every workshop session, before the students turn to the worksheet, the leader notes on the board the names of any who are missing. Late students erase their names when they arrive. Students volunteer information if they know why someone is absent. The careful record of attendance allows the leader to follow up quickly in the case of the student who has missed more than once. The leader may even go to the student's residence to find out why a student has not come and to offer help with any obstacles preventing attendance.

The first workshop meeting poses an especially delicate situation: unless the students see at once that the workshop can be useful to them, they will not wish to commit to it the extra hours it demands. Yet they can fully appreciate the benefits only gradually. Therefore, the first time--and perhaps the next few times--the leader will operate more traditionally, giving the students some bits of instruction that they can apply directly. The worksheet for the first day is designed to convince the students that they have to work hard but that the effort will result in their doing well academically. They are presented with problems related to the first homework assignment that initially they cannot solve, but that they can do easily once shown how.

While the students are becoming accustomed to studying together, the leader will employ various tactics to sharpen their critical responses. One such exercise involves having two or three students redo another student's written problem solution. They are asked to make small changes in language that they think will improve a test score. This task aims at showing them how to accumulate partial credit for style, even if they have a wrong answer.

At first, the students often discover that they are having a hard time communicating with one another. The leader may ask one member of a group to restate a concept more precisely or to explain in more detail the steps taken to arrive at an answer. By making their ideas clearer to the group, students clarify and reinforce their own understanding and find out what they have only superficially grasped. Paying close attention to how they express themselves also helps to improve how they will write on examinations.

In the last portion of the workshop, after the students have struggled with the worksheet, the leader will go over some of the problems they have all attempted. They can then evaluate alternative approaches and isolate key techniques. At this time they can raise questions about homework assignments and other concerns. To gain perspective on their efforts they are asked to consider how the material they have been learning fits into the course as a whole.

Before examinations the leaders will not only review sample test questions on the worksheets but also make suggestions to help the students organize their study outside the workshop: to figure out what should be memorized and what should not; to copy their lecture notes and fill in gaps; to reread the textbook; to check the textbook for clues to likely test questions. In order to develop their ability to allocate their private study time most efficiently, the students practice predicting what the test will look like--which questions will appear and how much certain questions might count in the grading.

As part of their continuing orientation, all the students in a workshop may attend cultural events on campus. From time to time the leaders may arrange for them to sit in on a lecture in a subject far removed from their regular classes, such as art history of the Renaissance or ancient Turkish poetry. These breaks from normal routine supply occasions for socializing as well as introductions to the varied resources of their environment.

E. Outcomes and Impacts

This section describes the results of a study conducted to compare the achievement of workshop students with that of other UC Berkeley students enrolled in the first-year math program. Our basic intent was to examine four questions: 1) how do the grades earned in mathematics by Black and Hispanic students differ, if at all, from those earned by white and Asian-American students; 2) to what degree are grades earned in mathematics the function of prior achievement in mathematics; 3) to what degree is membership in a workshop program associated with the level of achievement in mathematics, and 4) how much of the mathematics performance of workshop students is attributable to prior achievement in mathematics?

SAMPLE

The sample created to examine these questions was drawn from three separate populations of first-year students at UCB--whites and Asian-Americans, non-workshop Black and Hispanic students, and PDP Blacks and Hispanics ("Hispanics" are defined here as "Mexicans" or "those of Mexican descent"). A random sample of 191 white and Asian-American students was drawn from the rosters of students enrolled in first semester calculus (Math 1A). A total of 99 Black and Hispanic students were identified from comparisons of records maintained by the UCB Office of Admissions and Records (OAR) and the Math 1A class lists of the UCB Mathematics Department. All of these students were included in the sample.

DATA

Data collected for the study included: SAT Math and Verbal Score, Grade in Math 1A, race, and workshop affiliation. Also included in the study database (but not reported here) were a variety of other variables related to the student's academic performance in high school and at the University. A study of the relationship between these variables and academic performance/persistence at the University is in progress and is expected to be published in the spring of 1985.

DESIGN

The study described here is intended to be descriptive. It provides a picture of how the academic performance of students varied by race and workshop affiliation. As noted in an earlier section of this report, Black and Hispanic students have traditionally been at great risk of failure in mathematics at UC Berkeley, and one of the principal objectives in conducting this study was to determine how effective PDP's math/science workshop have been in reversing this trend. But a variety of factors mitigates against asserting that the workshops were the cause of the differences in student performance that were observed.

The first is that membership in the workshops was not randomly determined. Students may enter the program in a number of different ways including being recruited or simply requesting a chance to take part.

As a result, sample students cannot be said to have started the study on an equal footing academically. It is possible, in other words, that any differences in the performance of workshop and non-workshop students may be due to differences in factors that have no realtionship to workshop membership.

The second factor is that mathematics grades, unlike standardized test scores, are subject to considerable bias and are less than ideal measures of mathematics ability. The grades reported here were assigned by a variety of instructors. Thus, differences in their grading criteria render comparisons of their students problematic, to say the least.

However, the study does have important implications for policy makers. First, and most importantly perhaps, it does examine the relationship between SAT math score and actual performance in mathematics. SAT mathscores play an important role in admisssions decisions and in determining eligibility for calculus at UC Berkeley. Here, as is true at other colleges, a positive relationship between SAT performance and grades earned in calculus is presumed to exist. One important question that the study attempted to answer was the degree to which SAT scores actually predict minority student mathematics achievement.

The second fact is that although mathematics grades are less than perfect measures of student performance and ability, they are the standard against which students in college are judged and compared. Grades, it goes without saying, determine the student's fate in college. It is important, therefore, to determine how accurately and reliably we can predict who will succeed and who will fail in mathematics, particularlyif students can be denied admission to a course (or even to the college) based on this variable.

Math 1A grades were examined by race and by SAT scores. Students were grouped into the following categories: White/Asian non-workshop, Black/Hispanic non-workshop, Black/Hispanic workshop. SAT Math scores were also trichotomized: scores in the 200-400 range (bottom third); scores in the 400-600 range (middle third); and scores in the 600-800 range (top third). Contingency tables were created to compare students by race and workshop affiliation, SAT score, and mathematics grade. A chi-square statistic was computed for each comparison to test the null hypothesis that mathematics grades were independent of race, workshop status and SAT Math score.

RESULTS

As indicated in Table 1, PDP workshop students earned a greater proportion of grades in the A and B range than non-workshop students, irrespective of race. Moreover, no workshop student earned a math 1A grade below "C". By contrast, Blacks and Hispanics not in a workshop were substantially at risk of failure with 45.5. percent earning grades of "D" or worse.

Approximately 63 percent of PDP's Black and Hispanic students earned grades of "B" or better. Fifty-two percent of the Whites and Asian-Americans earned grades at this level, but only 30 percent of the non-workshop Black and Hispanic students performed comparably. (Table 1).

Of particular significance was the fact that these trends become more pronounced when the variable SAT math score is controlled. As indicated in Table 2, fully one half of the PDP students with SAT scores in the middle third (400-600) earned grades of A or B as compared with just 18 percent of the non-workshop Blacks and Hispanics and 28 percent of the Whites and Asian-Americans. Historically, students at UCB with SAT scores in this range do poorly, and non-workshop students with such scores were no exception. One-half of the Blacks and Hispanics and one-third of the Whites and Asians earned grades of D or worse. None of the PDP students, however, earned grades at this level.

PDP students with SAT scores in the upper third also outperformed their non-workshop peers. As shown in Table 3, 78 percent of the workshop students earned grades of A or B (as compared with 63 percent of the Whites and Asians and 55 percent of the non-workshop Blacks and Hispanics). No workshop students earned a grade below "C" while 18 percent of the Whites and Asians and 36 percent of the Blacks and Hispanics earned grades at this level.

CONCLUSIONS

Differences in the grades earned by workshop students differ both statistically and dramatically from those of non-workshop students. Membership in the program was clearly associated with high levels of achievement, irrespective of SAT score. Non-membership in the program for Blacks and Hispanics was associated with a high probability of failure that was only partially mitigated by having a SAT math score in the upper third of the distribution.

Whites and Asian-Americans with comparable SAT scores greatly outperform their non-workshop peers, but this advantage disappears when workshop student performance is considered.

As mentioned previously, these differences cannot be unequivocally attributed to the workshops. What is clear, however, is that PDP students with SAT scores in the "risk zone" have found a means to escape the doom that has traditionally been associated with scores in this range, and have managed to achieve a great deal more than would have been expected of them otherwise.

There is some speculation that the key to the successes described partially in these data is the mix of students with strong and weak mathematics background. Slightly more than 50 percent of the PDP workshop students in this sample were in the middle third of the score distribution with the remainder earning scores in the top third. The workshops are designed to maximize the strengths of the students who participate, so it is not surprising that students from all levels of the ability spectrum do well. However, evidence to support this contention is still being marshalled in the continuing study we are performing with these data.

F. Summary and Conclusions

1. The nation is currently in the midst of crisis, the dimensions of which were outlined in the National Commission on Excellence in Education's A Nation at Risk: The Imperative for Education Reform and the NSF/DOE report, Science and Engineering Education for the 1980's and Beyond. Both reports note that, at a time when the nation is desperately in need of trained scientists and engineers, the number of students entering college with the skills to complete these rigorous academic programs is declining. Worse, the number of minority students who have enrolled in undergraduate or graduate mathematics-related fields is declining, and those who do enter these majors, frequently fail to complete degrees in them. PDP's achievements in working with these students are all the more significant, given these dismal trends.

The roots of PDP's success are complex. It is sponsored by Berkeley's faculty under the auspices of its Academic Senate. One of its founders, Leon Henkin, is presently the chairman of Berkeley's Mathematics Department. One of Henkin's graduate students, Uri Treisman, designed the workshops. The program has been nurtured in an unusually rich mathematics environment.

2. PDP has also pioneered in the use of learning groups in mathematics instruction. The use of learning groups involves organizing students into small clusters of 4 to 6 students. Members of these groups are taught to work cooperatively together on mathematics assignments. Students critique each others' work, they discuss their approaches to problems and they test each others' mastery of the material. The process of talking about their struggles with the subject matter strengthens their understanding and mastery of the concepts. Group work also assists students in their social adaptation to college and frequently becomes the center of the social networks that students form. Significantly, PDP students persist in the University at high rates approximately 80 percent persist to their senior year and membership in the workshop program is believed to have played a crucial role in their retention.

In sum, PDP appeals to well-motivated, high-achieving students. It sets high goals for them, demands hard work from them, but organizes this work in highly efficient fashion. It teaches students to work both independently and in groups, and in so doing, prepares students for the kind of work conditions that are frequently encountered in research laboratories and high technology think-tanks the world over.

But in many respects PDP's methods are not as significant as its accomplishments. At the heart of the program's success is the assumption that Black and Hispanic students can succeed in mathematics if excellence is demanded of them and if means to achieve excellence are provided. The program demonstrates that Black and Hispanics can compete equally with the nation's very best students both at the University of California and elsewhere.

TABLE 1

FALL MATH 1A GRADES BY RACE, MEMBERSHIP IN WORKSHOP PROGRAM

	WHITES/ ASIANS	NON WORKSHOP BLACK/HISPANICS	PDP WORKSHOP BLACKS/HISPANICS
A & B	52.4	29.5	63.1
C	25.1	25.0	36.8
D & F	22.5	45.5	0.0

TABLE 2

FALL MATH 1A GRADES FOR STUDENTS WITH SAT MATH SCORES BETWEEN 400-600 AND 600-800 BY RACE AND MEMBERSHIP IN A WORKSHOP PROGRAM

(SAT MATH SCORE BETWEEN 400-600)

	WHITES/ ASIANS N=57 (%)	NON WORKSHOP BLACKS/HISPANICS N=26 (%)	PDP WORKSHOP BLACKS/HISPANICS N=10 (%)
A & B	28.1	18.2	50.0
C	38.6	30.8	50.0
D & F	33.3	50.0	0.0

TABLE 3

(SAT MATH SCORE BETWEEN 600-800)

	WHITES/ ASIANS N=131 (%)	NON WORKSHOP BLACK/HISPANICS N=11 (%)	PDP WORKSHOP BLACKS/HISPANICS N=9 (%)
A & B	62.6	54.6	77.7
C	19.8	9.1	22.2
D & F	17.6	36.4	0.0

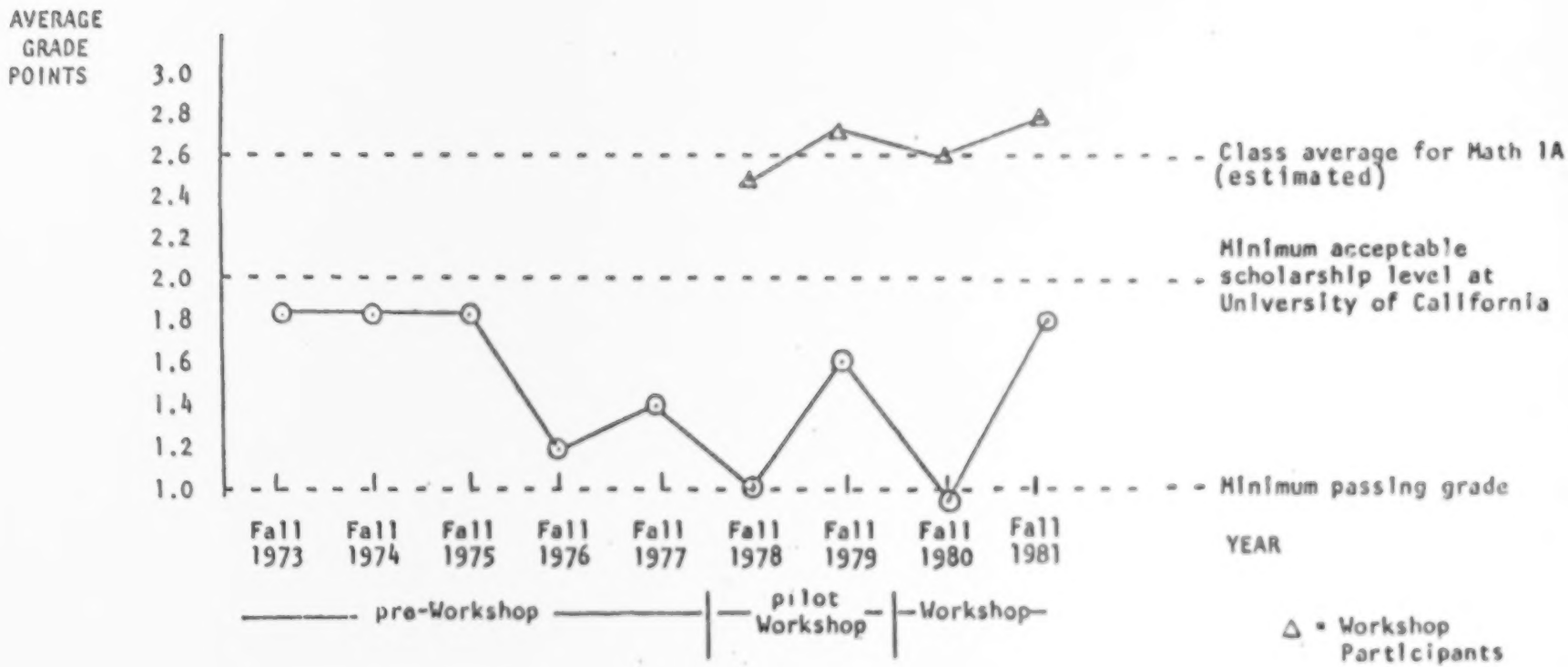
TABLE 4

PROPORTIONS OF BLACK AND HISPANIC STUDENTS EARNING GRADES OF "B" OR BETTER IN MATHEMATICS BY COURSE AND MEMBERSHIP IN A WORKSHOP PROGRAM

	COURSES		
	MATH P (%)	FALL MATH 1A (%)	SPRING MATH 1A (%)
NO PROGRAM	41.9 (N=67)	29.5 (N=44)	7.4 (N=27)
SLC	63.4 (N=41)	50.0 (N=36)	17.6 (N=17)
PDP	72.7 (N=33)	63.1 (N=19)	50.0 (N=22)

Chart 1a

PERFORMANCE OF BLACK FRESHMEN IN MATH 1A, BY YEAR



NUMBER OF BLACK FRESHMEN ENROLLED IN MATH 1A, BY YEAR

Year	1973	1974	1975	1976	1977	1978	1979	1980	1981
Workshop Participants	-	-	-	-	-	17	14	21	20
Non-Workshop Participants	10	12	21	23	22	22	16	17	7

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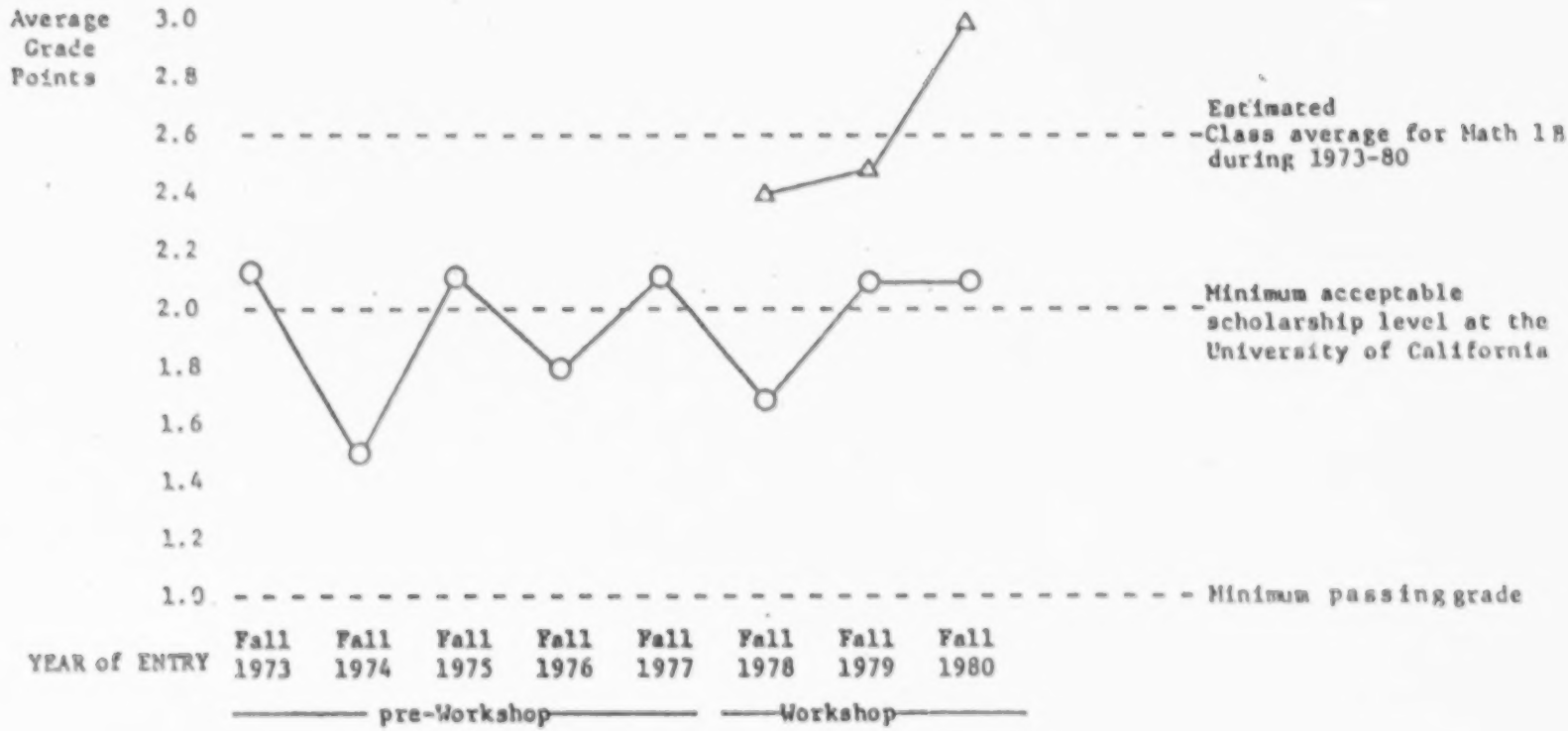
Chart 1b

Performance of Black Freshmen in Math 1B, by Year of Entry into the University



NUMBER OF BLACK FRESHMEN ENROLLED IN MATH 1B, BY YEAR

YEAR	1973	1974	1975	1976	1977	1978	1979	1980
Workshop Students	—	—	—	—	—	24	24	30
Non-Workshop students	9	15	20	19	22	14	18	11

△ = Workshop Participants

○ = Non-Workshop Students

Average Math SAT score of Black Workshop Students in Math 1B during 1978-80 was 529.
Average Math SAT score of Black Non-Workshop Students in Math 1B during 1973-80 was 544.

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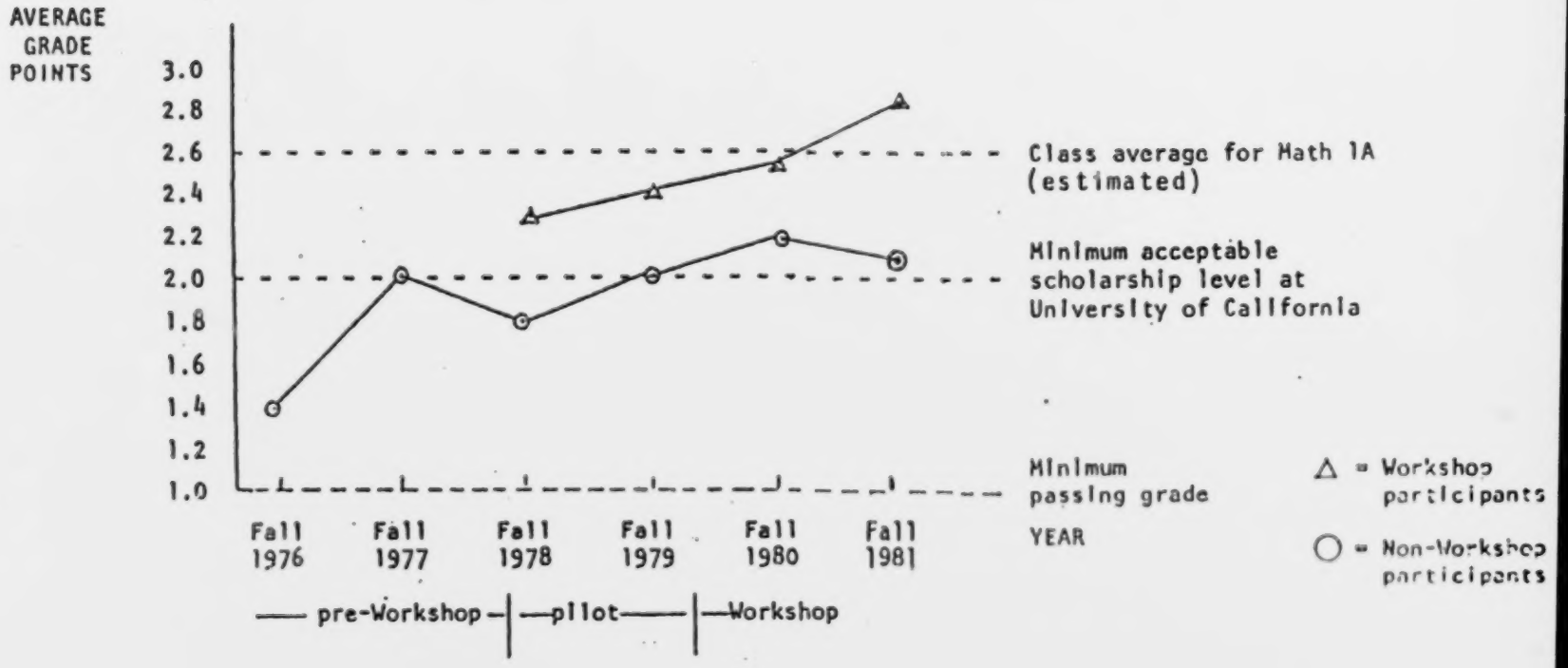
Chart 11a

PERFORMANCE OF CHICANO FRESHMEN IN MATH 1A, BY YEAR



NUMBER OF CHICANO FRESHMEN ENROLLED IN MATH 1A, BY YEAR

Year	1976	1977	1978	1979	1980	1981
Workshop Participants	-	-	5	4	13	13
Non-Workshop Participants	12	8	17	14	18	19

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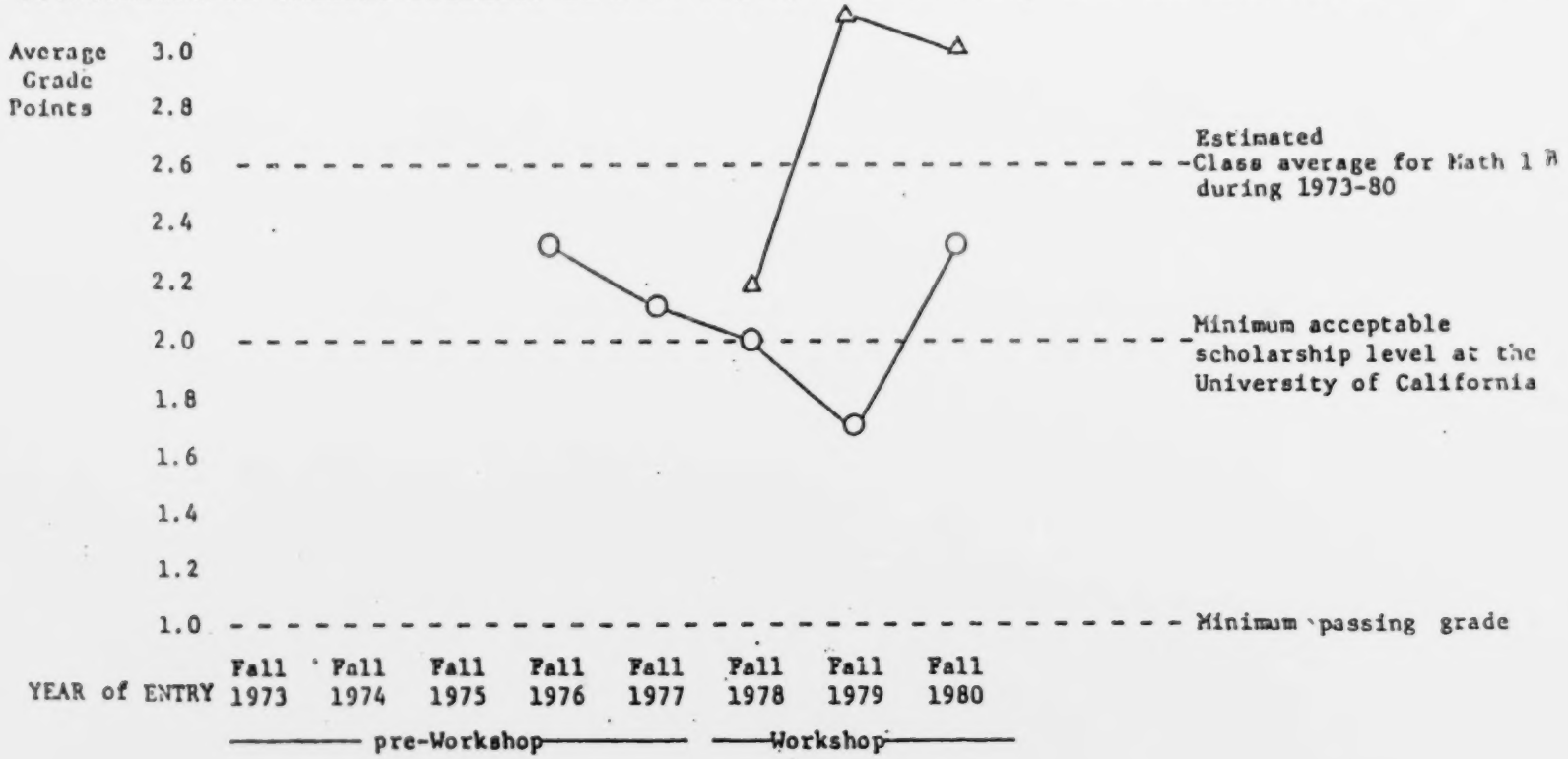
Chart 11b

Performance of Chicano Freshmen in Math 1B, by Year of Entry into the University



NUMBER OF CHICANO FRESHMEN ENROLLED IN MATH 1B, BY YEAR

YEAR	1973	1974	1975	1976	1977	1978	1979	1980
Workshop Students	—	—	—	—	—	7	6	16
Non-Workshop students	—	—	—	7	8	17	13	18

Δ = Workshop Participants

O = Non-Workshop Students

Average Math SAT score of Chicano Workshop Students in Math 1B during 1978-80 was 559.
Average Math SAT score of Chicano Non-Workshop Students in Math 1B during 1976-80 was 572.